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(54) A GAS-GAS HEAT EXCHANGER

(71) We, KUREHA KAGAKU KOGYO KABUSHIKI KAISHA, a Japanese Company of No. 8, Horidome-cho, 1-chome, Nihonbashi, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention generally relates to gas-gas heat exchangers, and more particularly to a gas-gas heat exchanger especially suitable for heat transfer to and/or from a corrosive gas.

A common use of gas-gas heat exchanges is for preheating combustion air by heat exchange with a hot exhaust gas from a furnace. However, hot exhaust gases from, for example, electric generator boilers or waste incinerators are usually released to the air without passing through a heat exchanger even though they have temperatures as high as 200°C. Obviously, it would be advantageous in most cases to recover heat from such hot exhaust gases by means of a suitable gas-gas heat exchanger. For example, a hot exhaust gas resulting from combustion of waste material, after being passed through a desulfurization process for removal therefrom of SO_2, is usually heated again by means of an afterburner or the like prior to being released to the atmosphere through a chimney as otherwise it would produce environmentally harmful white smoke. If there is a suitable gas-gas heat exchanger, the reheating of the desulfurized exhaust gas can be effected with the aid of heat from the hot exhaust gas, possibly without resorting to an additional heat source such as an afterburner. However, heat exchangers fabricated from metallic materials are not satisfactory in those cases where at least one of the gases between which the heat exchange is to be effected has an acid or other corrosive component. Although the problem of corrosion may be overcome by employing synthetic resin sheets as heat transfer means in place of metal plates, a difficulty has been found to occur in sealing the joints of the synthetic resin sheets and spacer means which space the adjacent synthetic resin sheets from each other by a predetermined distance.

The present invention has been made from a consideration of the above-noted problems.

The gas-gas heat exchanger in accordance with the present invention comprises:

upper and lower cover plates of a rigid material;

a plurality of heat-transfer sheets of a synthetic resin material interposed in spaced relationship with one another between said upper and lower cover plates and defining therebetween a number of substantially parallel heat-exchange channels;

a number of spacer members each coated with a synthetic resin film and interposed between said heat-transfer sheets along marginal edge portions thereof for maintaining adjacent heat transfer sheets in spaced relationship by a predetermined distance and in a hermetically sealed state;

a first gas inlet communicating with alternate ones of said heat-exchange channels through openings formed in said spacer members for introducing thereinto a heat-releasing gas;

a second gas inlet communicating with the other alternate ones of said heat-exchange channels through openings formed in said spacer members for introducing thereinto a heat receiving gas;

a first gas outlet communicating with said first gas inlet through said alternate ones of said heat-exchange channels;

a second gas outlet communicating with said second gas inlet through said other alternate ones of said heat-exchange channels; and

clamping means for clamping said upper and lower cover plates together.

The heat-transfer sheets used in the apparatus of the present invention are of a synthetic resin material which, of course, should have a resistance adequate to the intended purpose. For many applications, suitable materials are polyvinylidene fluoride, polyvinyl fluoride, polyfluoroethylene, polytrifluorochloroethylene and copolymers of polyvinylidene fluoride and hexafluoropylene. The heat-transfer sheets may consist of resin sheets alone or they may have a composite construction in which other materials are used. For example, they may have a sandwich construction in which there are outer layers of a synthetic resin material as mentioned above and an inner layer of a metal sheet or mesh for example, or aluminium. Another useful composite heat-transfer sheet consists of carbon fibre dispersed in a continuous film or sheet of synthetic resin material.

The thickness of the heat-transfer sheets is not critical but often they will have a thickness in the range of from 0.3 mm to 2 mm, and the range from 0.5 mm to 1.5 mm is generally preferred. Of course, the rate of heat exchange between the two gases is enhanced by using thin heat-transfer sheets, but on the other hand the sheets must possess adequate strength. For this reason it is normally preferred to employ a thickness of not less than 0.5 mm, particularly if the gases are to be passed through the heat-exchange channels at a velocity greater than 5 m/sec. Also, where the heat-transfer sheets have a composite construction using a combination of a synthetic resin and a metal sheet or carbon fibre, it may be technically difficult to produce sheets with a thickness smaller than 0.5 mm.

The synthetic resin films which coat the spacer members are preferred to be securely welded to marginal edge portions of adjoining heat-transfer sheets. Such welding may be facilitated by choosing for their coatings a synthetic resin material similar to that of the heat-transfer sheets.

The gas inlets and outlets may be formed from a metallic material but, in that event it is preferred that they should be lined with a synthetic resin material to protect them against corrosion.

The invention will now be further described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view showing the general construction of a gas-gas heat exchanger according to the present invention;

Figure 2 is a sectional view taken along line II—II of Figure 1, showing spacer members which are interposed between marginal edge portions of adjacent heat-transfer sheets;

Figure 3 is a fragmentary sectional view taken along line III—III Figure 1, showing on an enlarged scale the welded seals between the heat-transfer sheets and the respective spacer members; and

Figure 4 is a fragmentary sectional view taken along line IV—IV of Figure 1, showing on an enlarged scale the construction of a gas inlet of the heat exchanger.

Referring to the accompanying drawings and first to Figures 1 and 2, the gas-gas heat exchanger 10 there shown includes upper and lower cover plates 11 and 12 of a rigid material and generally of a rectangular shape and a number of heat-transfer sheets 13 of a synthetic resin material of good resistance to chemicals and heat, for example one of the polymers mentioned hereinbefore interposed between the upper and lower cover plates 11 and 12. The heat-transfer sheets 13 are spaced apart by means of spacer members 14 each which is in the form of a rectangular frame holding the marginal edge portions of adjacent heat-transfer sheets a predetermined distance from each other to provide a number of substantially parallel heat-exchange channels 15 on opposite sides of the respective heat-transfer sheets 13. The spacer members 14 are coated with a film 16 of a synthetic resin material similar to that of the heat-transfer sheets 13 and welded to the latter, for hermetically sealing marginal edge portions of the four sides of the heat-exchange channels 15.

The upper and lower cover plates 11 and 12 are releasably clamped together by means of bolts 17 holding securely therebetween the welded assembly of the heat-transfer sheets 13 and the spacer members 14.

In the particular embodiment shown, the clamping bolts are positioned outside the assembly, however, they may be passed through the spacer members 14, if desired. The heat exchanger 10 may have a shape other than rectangular, but a rectangular shape is preferred from the standpoint of its functions.

A first gas inlet 18 for a heat-releasing gas communicates with alternate ones 15a of the heat-exchange channels through openings 19 formed in the spacer members close to one end of the exchanger 10, and a second gas inlet 20 for a heat receiving gas communicates with the other alternate ones

15b of the heat-exchange channels through openings 21 similarly formed in the spacer members 14 close to the other end of the heat exchanger 10.

For exhausting gases which have passed in heat exchange relationship through channels 15a and 15b respectively, there is provided a first gas outlet 22 which is communicated with the channels 15a through openings (not shown) formed in the spacer members 14 close to the one end of the heat exchanger 10 and opposite the second gas inlet 20, and a second gas outlet 23 which communicates with the channels 15b through openings (not shown) formed similarly in the spacer members 14 close to the other end of the heat exchanger 10 and opposite the first gas inlet 18. Thus, in the particular example shown, the heat exchange is effected in counterflow, that is to say, one gas Ga is introduced into the exchanger through the gas inlet 18 and discharged therefrom through the gas outlet 22 while the other gas Gb is introduced into the heat exchanger through the second gas inlet 20 and discharged therefrom through the second gas outlet 23. However, if desired, the heat exchanger may be constructed so that both gases flow in parallel therethrough.

The films 16 which coat the spacer members 14 preferably are formed of a synthetic resin material having properties which allow sealing of the heat-exchange channels 15 simply by pressing or welding together the heat-transfer sheets 13 and the respective spacer members 14. A secure seal can then be obtained by interposing a heat-transfer sheet 13 between films 16a and 16b an upper and lower spacer members 14a and 14b and welding or pressing together the three layers under heating conditions, as shown particularly in Figure 3. In this way, it is possible to construct a heat exchanger in which the heat exchange is effected without any gas leakage or corrosion of the space members.

In the particular example shown in Figures 3 and 4, the heat-transfer sheet 13 has a sandwich construction consisting of outer layers of synthetic resin material 13a and an inner layer of a metal sheet 13b.

The spacer members 14, in other words, the distance between the adjacent heat-transfer sheets 13, should have a thickness as small as possible, preferably in the range of from 5 mm to 20 mm, to provide an increased number of heat transfer surfaces in a given volume. In this connection, the heat-transfer sheets 13 are not necessarily required to have flat surfaces and they may, for example, have wavy or other surface configurations except for those portions which are sandwiched between the respective spacer members, for the purpose of providing increased heat transfer surface areas.

The gas inlets and outlets 18, 20 and 22, 23 are similar in construction, and therefore only the first gas inlet 18 will be described in detail hereinafter with reference to Figure 4. The first gas inlet 18 includes a rectangular body 24 of a metallic material and having a flanged end 25 for connection with a gas feed duct (not shown).. The inner surfaces of the gas inlet 18 are lined with a film or sheet 26 of a synthetic resin material to protect them against corrosion.

As shown in Figure 4, the inner end of the gas inlet 20 is securely connected to the upper and lower cover plates 11 and 12 by suitable connecting means such as bolts together with the protective cover film 26 which are sealingly welded to the uppermost and lowermost heat-transfer sheets 13.

The hot gases to be introduced into the heat exchanger of the invention should not have temperatures which exceed the design level for the synthetic resin material used for the heat-transfer sheets 13. Where the heat-transfer sheets 13 are formed from a synthetic resin alone, the hot gas should have a temperature below the softening point of the synthetic resin material. On the other hand, with heat-transfer sheets of certain composite constructions, the hot gas may have a temperature close to the melting point of the resin material of the composite sheets. More particularly, we have confirmed that it is feasible to pass a hot gas of 150°C at a velocity of 10 m/sec. for about 1,000 hours through heat-exchange channels formed by heat-transfer sheets which consist solely of polyvinylidene fluoride having a melting point at 180°C. Furthermore, heat-transfer sheets in the form of a composite construction including outer layers of polyvinylidene fluoride and an inner layer of an aluminium sheet stand up to a hot gas having a temperature as high as 180°C.

WHAT WE CLAIM IS:—

1. A gas-gas heat exchanger comprising: upper and lower cover plates of a rigid material;

a plurality of heat-transfer sheets of a synthetic resin material interposed in spaced relationship with one another between said upper and lower cover plates and defining therebetween a number of substantially parallel heat-exchange channels;

a number of spacer members each coated with a synthetic resin film and interposed between said heat-transfer sheets along marginal edge portions thereof for maintaining adjacent heat-transfer sheets in

spaced relationship by a predetermined distance and in a hermetically sealed state;

a first gas inlet communicating with alternate ones of said heat-exchange channels through openings formed in said spacer members for introducing thereinto a heat-releasing gas;

a second gas inlet communicating with the other alternate ones of said heat-exchange channels through openings formed in said spacer members for introducing thereinto a heat receiving gas;

a first gas outlet communicating with said first gas inlet through said alternate ones of said heat-exchange channels;

a second gas outlet communicating with said second gas inlet through said other alternate ones of said heat-exchange channels; and

clamping means for clamping said upper and lower cover plates together.

2. A gas-gas heat exchanger according to claim 1, wherein said synthetic resin film coatings of said spacer members are welded to the marginal edge portions of said heat-transfer sheets.

3. A gas-gas heat exchanger according to claim 1 or claim 2, wherein said heat-transfer sheets are of a composite construction.

4. A gas-gas heat exchanger according to claim 3, wherein said heat-transfer sheets comprise a sandwich construction having an inner layer of a metal sheet or mesh and outer layers of a synthetic resin.

5. A gas-gas exchanger according to claim 3, wherein said heat-transfer sheets are synthetic resin sheets containing carbon fibre.

6. A gas-gas heat exchanger according to any preceding claim, wherein said heat-transfer sheets are formed from a synthetic resin material selected from polyvinylidene fluoride, polyvinyl fluoride, polyfluoroethylene, polytrifluorochloroethylene, and copolymers of polyvinylidene fluoride and hexafluoropropylene.

7. A gas-gas heat exchanger according to any preceding claim, wherein said heat-transfer sheets have a thickness of from 0.3 mm to 2 mm.

8. A gas-gas heat exchanger according to any preceding claim, hwerein said spacer members are coated with a film of a synthetic resin material selected from polyvinylidene fluoride, polyvinyl fluoride, polyfluoroethylene, polytrifluorochloroethylene and copolymers of polyvinylidene fluoride and hexafluoropropylene.

9. A gas-gas heat exchanger according to any preceding claim, wherein said heat-transfer sheets have a wavy surface configuration to increase their heat-transfer surface area.

10. A gas-gas heat exchanger according to any preceding claim, wherein said gas inlets and outlets are provided with a protective cover film of a synthetic resin material.

11. A gas-gas heat exchanger according to claim 10, wherein said gas inlets and outlets are sealingly mounted in position on said exchanger and said protective cover films are securely welded to the uppermost and lowermost heat-transfer sheets.

12. A gas-gas heat exchanger according to any preceding claim, wherein said heat-transfer sheets are spaced from each other by a distance of from 5 mm to 20 mm.

13. A gas-gas heat exchanger according to any preceding claim, wherein said cover plates are of generally rectangular shape.

14. A gas-gas heat exchanger substantially as hereinbefore described with reference to the accompanying drawings.

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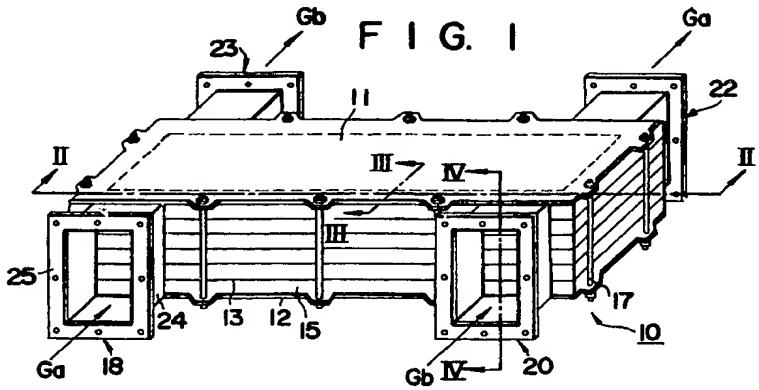
1468410 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

F I G. 1



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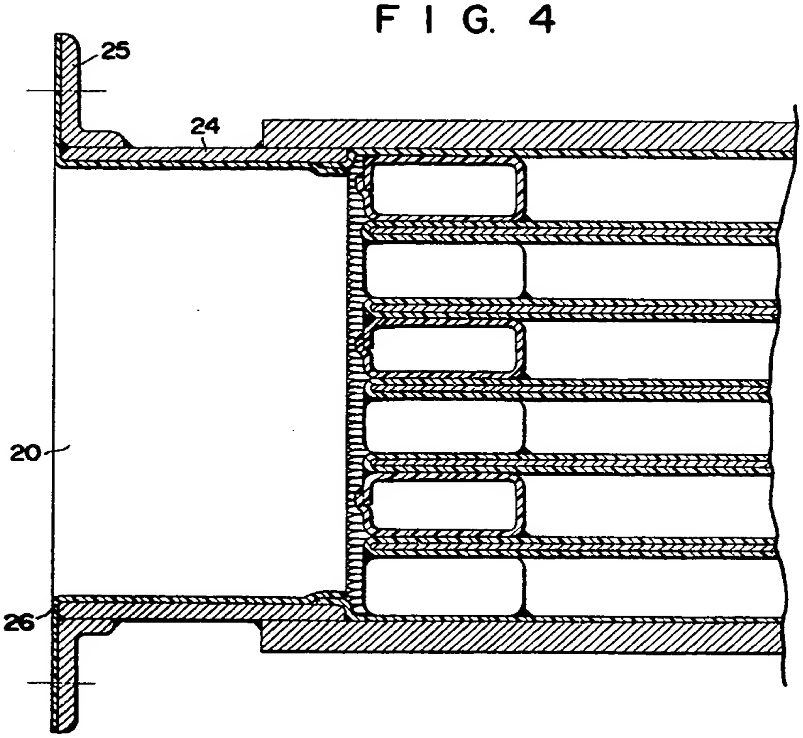
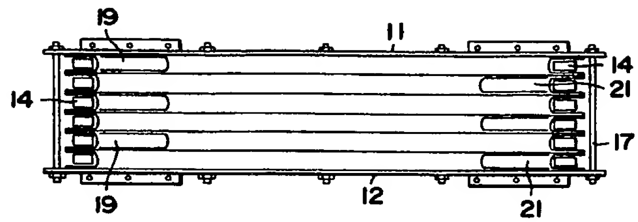


1468410 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

F I G. 2



F I G. 3